Dec 10th, 12:00 AM

Design Drift and Reflective Conversation in Design Science Research: A Case Study of Problem Formulation

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Completed Research Paper

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Abstract

Design Science Research is a well-established theoretical and methodological approach to design, build, and evaluate IS artefacts. However, research suggests that the engagement of subjective and ethereal processes of design are not well documented in literature, highlighting a significant challenge to understanding design praxeology, or the study of practices and processes of design. This paper explores the artefact conceptualization stages of DSR using a case study focused on the utilization of emergency management information systems to propose two approaches to understanding and presenting the design process. Design drift and reflective conversation are proposed and applied to a DSR project to create a conceptual design for a mindfulness-based evaluation framework for EMIS supported decision making. By removing some of the mysticism often associated with abductive reasoning, the study demonstrates ways researchers can be more effective in using cognitive mapping tools and communicating approaches to illustrate the inferential processes that are unique to DSR

Keywords: Design Science, Problem Formulation, Emergency Management Information Systems, Organizational Mindfulness

Introduction

Design science research (DSR) in IS aims at 'utility' as opposed to 'truth' through the conceptualization, construction, and evaluation of "generic means-ends relations (pg. 470, Winter, 2008)" of a research

problem with a focused objective of the creation of a solution to that problem (Peffers, 2007). The problem formation stage of DSR provides the context and constructs within the application domain environment under scrutiny by the eyes of experience or novice design researchers (Hevner, 2007). As a theoretical approach to investigating issues and finding solutions to common and sometimes, not so common problems, DSR is both appropriate and illusive. Design can be done in the company of other stakeholders or in the confines of reflective contemplation with iterations of concepts and artefact possibilities produced through processes of ideation. These are the seeds for designing IS artefacts, the use of shapes to show relationships, arrows to illustrate interactions, colours to emphasize as the designer builds the artefact as a representation of the problem and solution (Cross, 1999; Peffers et al, 2007). Conversely, there is little research communicating the exploratory process associated with design used to determine relevance in the problem space and theory building in the solution space. It is just described as a necessary activity or process in DSR (Hevner, 2007; Walls et al, 1992; March and Smith, 1999). While processes that are used to design, build and evaluate an IS artefact are the core objectives of using the DSRIS methodology, we explore design praxeology, or the practices and processes of abstraction in the design of an IS artefact. The goal of this paper is to describe the co-evolutionary process between the problem and solution space that designers flow between to obtain an assessment and understanding of both spaces in the creation of an IS artefact. While there is large body of guidance for the undertaking of various stages of DSR, there is limited literature providing an accounting of the iterative activities which occur in the problem ideation stage. The methodological processes employed for artefact construction are described here as design drifting and reflective conversation. These processes are used to improve our understanding of the ideation stages of DSR to reduce the mystery of abductive reasoning to guide problem formulation for an application domain.

This paper describes the application of DSR to create a conceptual design for the meta-requirements of a mindfulness-based evaluation framework for system enabled decision making. The case study uses organizational mindfulness (OM) in the construction of an evaluation framework to assess the effectiveness of emergency management information systems (EMIS), a specialized group decision support systems (GDSS) used to support decision making and situational awareness in the application domain. The research and learning approach applies design heuristics for problem exploration and solution ideation to discuss the parameters which bind our problem and solution spaces. The next section provides a discussion of the prescribed DSR methodological approach that is employed for the purpose of designing, building, and evaluating our IS artefact during the design phase. Section 3 provides an orientation of OM, group decision making, and system utilization within high reliability organization (HRO) environments which are used to build the constructs of the framework. To determine if the problems that are observed are not aberrations derived from the imagination of the designer, a series of pilot studies were conducted for problem validation. Section 4 illustrates the approach used by the designer to validate the constructs associated with EMIS utilization that inform the design of the artefact. Section 5 describes the output of this ideation stage in the form of meta-requirements for the evaluation framework and next steps proposed in the DSR journey: building the IS artefact. We hope to further DSR teaching and learning by presenting a learning approach to visualise linkages in design, system utilization, and team performance. By communicating the phases and processes associated with design, we ultimately enhance our understanding of the abductive process and better position the philosophical stance of DSR in IS. The paper contributes to the body of DSR literature by providing an approach towards design praxeology that is fruitful for generalizing knowledge about application domains to inform how we engage in the iterative cycles of design.

Design Science Research Methodology (DSRM)

DSR has matured to be viewed as both a heuristically sound theoretical approach (Gregor and Jones, 2004; Venerable, 2006) and research methodological paradigm (Hevener, 2007; Peffers et al, 2006). This section provides an overview of DSR methodology and design praxeology as a focal point of this research.

Overview of DSR in Information Systems

The baseline premise of rote learning in DSR is understanding that the major purpose of IS is to improve the effectiveness and efficiency of an organization (Hevner et al, 2007). DSRIS researchers emphasize an orientation to knowledge acquisition, theory building, and research methodology which is unique to other natural or social science orientations. The science of design, as theorized by Simon (1969) and described by Baskerville (2008) as a study of the "systematic creation of knowledge about and with design (pg. 441)."

Baskerville espouses on the novelty of design science in the IS arena where design is central to solving theoretical and pragmatic problems. Simultaneously, it is central to the activity of building knowledge about design. Though design science is not design, design theory, an IT artefact, methodology, action research, computer science, or separate academic discipline, it is the acquisition of knowledge about how we abstract a perception of reality from our environment to inform the creation representations of that reality (Winters, 2008). Simon's *Science of the Artificial* has inarguably produced an enriched and enriching axiom for the pursuit of knowledge, where it "resides in the product (pg 6, Cross, 1999)" and not just in causal relationships which influence how the artificial product is constructed, used, or discarded. As a methodology, DSR is described by Cross (1999) as the study of the processes of design, development and application of techniques to aid design. His work produced the first ontological categories of a design taxonomy for the epistemology, praxeology, and phenomenology of design. This knowledge of design from other fields, such as engineering, are furthered explored and applied here to bind and legitimize DSR as a philosophical stance concerned with the nature of IS artefacts and relations of being (Schone, 1991; Gregor and Jones, 2004; Gregor, 2006). The outcome, sometimes called outputs, of DSR are abstracted levels of knowledge gained through the use of theory about a phenomena for the construction of operational principles and artefacts which are also abstractions based on its situated implementation (Vaishnavi and Kuechler, 2004).

There is a rich body of DSR literature discussing the differences between design theory (Gregor and Jones, 2004) as opposed to a research paradigm with a development and testing process (March and Smith, 1995) or research wedged between those two positions (Walls, et al, 1992; Vaishnavi and Kuechler, 2004). Theory and theorizing are recognized as critical components of any DSR approach (Nunamaker et al, 1991, Veneable, 2006) to generate IS products and new knowledge about design, yet its importance is not diminished in the engagement of often subjective and ethereal processes prescribed for conducting research. We will first discuss the DSR methodology that is used in this case endeavour before we explore the core focus of this paper, design praxeology. Acknowledging a critical understanding of design theorizing, this paper builds on the body of work of Walls et al (1992) and Veneable (2006) in examining the use of design theory to evaluate problem situations and judge the relevance of technology in providing an appropriate solution to those problems. The goal orientation and solution seeking which is characteristic of the philosophical stance of DSR, is reflective in the methodological approach to the construction of a proposed artefact that is both theoretical and application based. We argue that theory building and methodology are so closely intertwined in DSR, that communication of the design process presents a unique challenge for researchers. Hevner (2007) provided one of the seminal frameworks to conduct and report DSRIS based on three "inherent" research cycles which guide the iterative design cycles of this research: *Relevance, Design, and Rigor*. The *Relevance Cycle* establishes the contextual environment to understand what he describes as the application domain, or the people, organizational systems and technical systems where problems and opportunities for design are explored. The *Design cycle* is intended to be the core activity of designing, building, and evaluating an artefact in process driven iterations. The *Rigor Cycle* connected the activities of design to the contribution to the knowledge base through grounding or adding to theories and methods. While this work formulated the methodological focus for the IS community, it did not go into depth as to the processes of design itself.

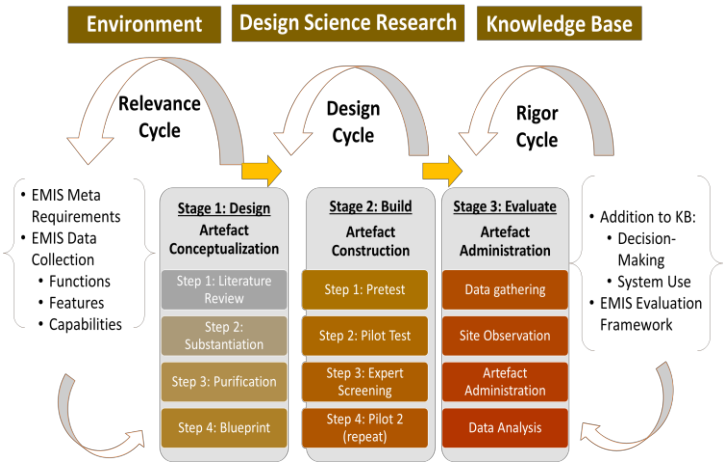

Figure 1 Design Science Research Cycle (adapted from Hevner, 2007)

As DSR in IS has matured for over a decade, so has guidance for the development, production, and dissemination of DSR within the research community. Figure 1: DSR Cycle, adapts Hevner (2007) design science research cycles for the purpose of applying it in the construction of our artefact. A novice researcher would be cautioned to assume that the cycles and processes of DSR are clear despite guidance proposing stages, steps, and products (Rossi and Sein, 2003). Due to the role that "experience, creativity, intuition and problem solving capabilities of the researcher (pg. 76, Markus et al, 2002)" plays in any DSR endeavour, the process is a reflective journey, subjective in nature. The following diagram is used to illustrate the approach taken by researchers to frame how the proposed IS artefact would manifest from stages of conceptualization (Design) to construction (Build) and implementation (Evaluate). The focus of this paper is in the artefact conceptualization stage of research providing an accounting of the initial ideation stages of DSR used for problem identification, motivation, and forming solution objectives (Peffers et al, 2007). Using a fluid step-wise approach, conceptualization occurs through building a knowledge base from literature associated with the application domain and substantiating assumptions about problems, concepts, and variables associated with EMIS utilization. Purification of these notions are constructed within the ideation space to distil, extract, and contextualize an understanding of the phenomena of interest through engagement with members of the application domain. The resulting blueprint of the conceptualization manifests as a model for conducting research and structuring the DSR study to progress towards the *Build* stage. The remaining sections of this paper proposes consideration of methodological approaches to understand and document the creative processes within the *Design* stage.

Design Praxeology

Gero and McNeill (1998) purported that little research explores how designers actually designed and proposed a methodology based on protocol studies to investigate the design process. Since the development of that behavioural-structure model, the design science community outside of IS has benefited from empirical research furthering knowledge of design praxeology, or *the study of practices and processes of design* (Cross, 1999). The design process has been described as an introspection or abstract form of hypothesis with limited research on "capturing, presenting and analysing the activity of designing (pg. 40)" as a form of phenomena to be modelled or wherewith to develop explanatory theory. What occurs in the design process is a drifting between the problem space and the solution space, as the designer navigates issues and considerations in both spaces to inform the design of a IS artefact, fit for its purpose. We consider the description of conceptual design by Gerro and McNeill (1998) as one of the first places where drifting between the problem and solution space occurs in the form of a tangible expression of the design process:

> *"The conceptual design process can be considered as one in which the designer navigates through an abstract problem domain and employs various strategies to elaborate the problem description. In order to give a richer representation of the design process a distinction is made between the designer's place in the problem domain and the strategies used by the designer during the design process (pg 23)"*

The authors continue to describe the multiple dimensions in which a designer navigates to obtain a model to express the reasoning behind the proposed design, and the designed artefact simultaneously. As a novice design researcher, reading design science literature could present a unique set of daunting challenges to be considerate of during the conceptual design phases of developing an artefact. There is a form of mysticism involved with the "methodological" approaches to design, where subjectivity and reflective appreciation towards the development of a solution is encouraged over objective reasoning of a problem. Other scholars have described this as the solution orientation which drives the pursuit of knowledge in this research paradigm (Cross, 1999; Gregor and Jones, 2004, Venable et al, 2012). Through processes of inductive and deductive reasoning may be employed, the designerly way of acquiring knowledge relies on the application of techniques which require abductive reasoning and abstraction to construct the designed artefact to meet the needs of described problem with a prescribed solution.

Design was also described by Schön (1991) as a reflective conversation where the designer responds to the demands of a conceived problem in a space of creativity that materializes constructs and reconstructions of objects and their relationships in cyclical design episodes which can be singular or communal in nature. The praxeology of design extends from the imagination of the designer to the practicality of a solution application in a proposed space through the use of actual or virtual representations. The initial stages of this reflective conversation were argued to be engaged through an active sensory appreciation of these representations of the design situation. The intelligent action that allows for the creation in the design world is rather subjective and selective. In discussing the innovation of design episodes, Schön purported, "the more a design episode is innovative-the more it changes the world or the way we perceive the world-the more likely, in the first instance, to be unique to the designer (pg 4-5)." Between the problem and solution space was the activity of designing an artefact with the purpose of evaluating other designed instantiations which address the complexity of organizational process that engaged by teams using designed systems. The goal of *drifting* in the context of this research, is to "purposeful seek a solution (Cross, 1999)" in the design of a framework that forms new knowledge built upon an awareness of the problem space with a simultaneous exploration of the knowledge stored within the designed artefact itself (pg. 6). This notion further confirms an axiom that Albert Einstein eloquently stated "all creation waits with eager longing for the revealing…," and through reflective revelation, a designer is able to create an output which materializes an abstraction of a solution. We operate in the stream of thought proposed by Veneable (2006), where a "design method should itself be considered to be an IT artefact that can be designed and constructed (pg. 12)." For the purpose of our exploration of the products of design drifting and reflective conversation, the next section discusses some base line problems which informed our understanding of the problem and solution space to consider that an evaluation framework would be the appropriate solution, meeting an internal evaluation criteria (Rossi and Sein, 2003).

Problem and Solution Space Framing an Evaluation Framework

While the design process may come across as ephemeral and abstract, it's the focus on using *real systems* to solve *real problems* (Sun and Kantor, 2006) which orients DSR as the appropriate approach to endeavour in reflective conversations about high reliability organizations (HROs). The Relevance cycle should be the strongest motivator for DSR, as it "initiates [DSR] with an application context that not only provides the requirements for the research as inputs but also defines acceptance criteria for the ultimate evaluation of the research results (pg. 89, Hevner, 2007)." The use of conceptual processing and mental models is encouraged in DSR literature (Veneable, 2012; Peffers et al, 2012) to support the problem identification stage. This approach, used by the designer, sought to reflect on the artefact construction based on an awareness and understanding of the problem space. Awareness and understanding derived from over ten years of experience as a practitioner in the EM domain strongly influenced design attributes of the artefact construction.

An examination of operations research, emergency management, and information system literature revealed a lack of consensus on ways to evaluate system supported decision making indicative to this domain. The problem that we seek to address in the case study is the lack of clarity that the IS research community has about the effectiveness of specialized systems used for decision making to ensure reliable, or repeatable, team performance within the EM domain. The environment in which these systems operate are described as requiring highly adaptable organizational structures and processes to respond to often volatile and dynamic events (Weick and Sutland, 2006). There is general acceptance among IS researchers in the emergency management (EM) domain that for computer based systems and their design to be effective and adapted for decision support in this arena, there should be base understanding of the

"cognitive process" involved in responding to unexpected events (Mendonca et al, 2001; Hiltz, 2011). While the emergence of technological capabilities such as data analytics are suggested to support cognitive processes, the extent at which they are effective in supporting group decision making indicative of this application domain are still not well understood. There is substantial body of IS literature that informs of how best to evaluate specialized systems in the context of their intended use (DeLone and McLean, 2003; Venkatesh and Davis, 2000; Venkatesh et al, 2003), yet there remains a gap in evaluating the extent to which these systems enhance organizational practices of EM group performance correlated to system use for this application domain (Turoff, 2008).

Literature continues to call for a collective agreement among practitioners, developers, and policy makers on systematic and functional requirements of EMIS to ensure the interoperability of systems among the multiple agencies and organizations engaged in emergency response (Belardo et al, 1984; Dorsemy, 2011; Van DeWalle, et al., 2009). The designers elected the use of a concept centric map to illustrate both the complexity and the importance of the problem that has been identified with EMIS used for decision making. The entry point to this DSR project was through a problem centred approach and objective centred solution (Peffers et al, 2006) to provide a mental model of the problems within the application domain, yet framed with an awareness of possible solutions. Based on an understanding of the domain, selection of another solution technology was not considered the best approach to evaluate how well an artefact (i.e, EMIS with GDSS capabilities) performs their task (March and Smith, 1995). As noted in Veneable (2006) theorising in DSR may begin with a spark of an idea or through cognitive processes involved with reasoning on the purpose and action of a solution artefact (Gerro and McNeill, 1998). Engaged with the orthogonal dimensions of design reasoning, we approached binding the application domain in a way that extrapolated from a review of literature on technology used in the EM domain oriented from a practitioner's perspective, illustrated in the Figure 2: EMIS Utilization Concept Map.

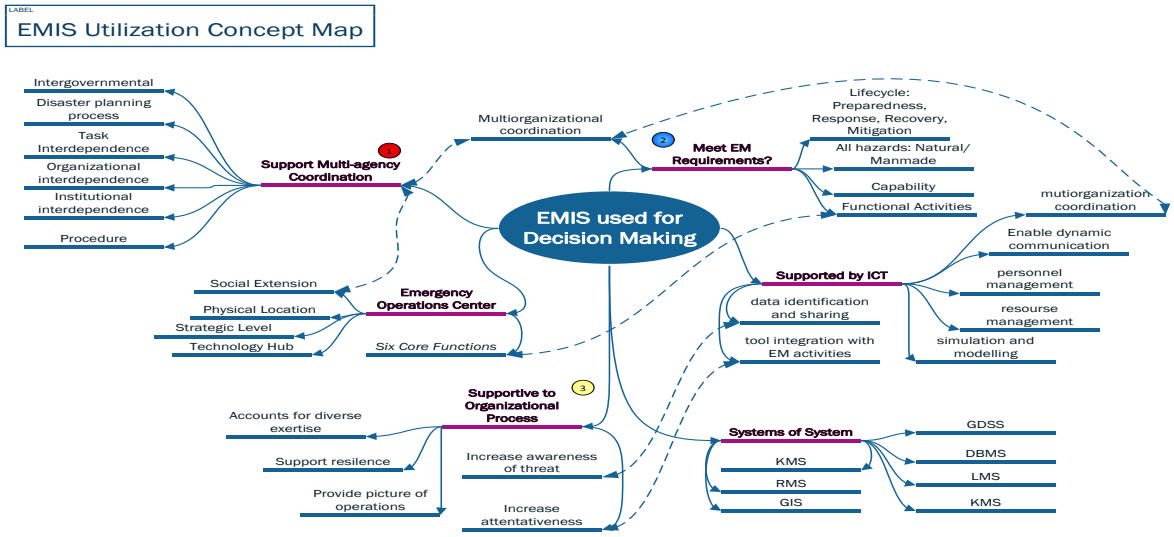

Figure 2 EMIS Utilization Concept Map (created by researcher)

The contemplation process of the concept mapping exercise can be considered a muddy one where mapping serves as a tool for visualising the complexity, or elements, of the problem focus. In this case, Figure 2 illustrates how EMIS is used for decision making within the EM domain, the elements which both influence, enable, and impact this core activity. The use of mapping as a praxeological approach to initiate the investigation relied on reflecting on experiential knowledge and exposure to both low impact and high profile emergency response situations where EMIS were integrated in operational activities. For instance, consideration of the training requirements associated with orienting users with these systems within EM organizations is often aligned to the operational processes developed and executed for response. As a practitioner this would include aligning activities such as shelter management into the resource modules of an EMIS, or training decision makers on the interface modules of the system to monitor an incident remotely. Contemplation on the space where EMIS is most commonly used for decision making found that the operational centre served as a focal point for social and facility-based interactions among decision

makers. Deduction of the activities, interactions, and dynamics of groups engaged in real-time, fast-paced decisions which were critical to the life and safety of communities is visualized using interconnecting arrows which tie technological features and functions with organizational goals and processes. The numbers are used to indicate an impression of the most important attributes of EMIS use based on an awareness of the domain. Whether based on a regulatory framework which dictated these activities, or an emphasis on the delicate balance associated with coordinating multiple agencies, a concerted effort is built to identify and situate items in the map that are associated with in the problem space. The tacit knowledge of the domain is visually displayed in an abbreviated map to transfer an understanding of sensory derived experiences, insights, observations, and impressions of technology used to support moving ambulances to the scene of a train derailment or to report the number of citizens evacuated from a flood area. The precision and accuracy required to build a collective awareness of an emergency situation is placed to the wayside for processes to conceptualise, analyse, and ideate a frame for artefact design. Targeting the use of EMIS within the domain centred cognitive contemplation and speculation in an objectively constrained manner to construct within the context of the problem space. The concept map manifests as an iterative circumscription to derive meaning and significance for the creative process in a controlled manner to progress understanding and prescribe a solution to an identified problem.

Transition out of the contemplation of a highly contextualized, socio-technical environment towards the iterations of construction are anchored in the objective oriented processes of DSR to substantiate the ideation stage. The design science research process (DSRO) framework model (Peffers, et al, 2007) was used to engage in the initial activity of articulation of the identified problem and solution objective. The way in which we were able to formulate declarative statements about the problem space were derived from both an reflection of experience and exploration of literature while leveraging the intuitive knowledge about the application space gained from exposure and experience. This formulation using a concept map helped in refining the boundaries of the problem and solution space, as follows:

Problem Identification EMIS designed to perform specific functions for a group within single organizations may fail to provide the same level of support when multiple agencies are performing multiple functions (Belardo et al, 2003). *Are the EMIS being used (or designed) effective at supporting the core function of decision making among coordinated groups?* Efforts and solutions to address systematic/technical barriers to interoperability continue to site the challenge of organizational interoperability, or multi-agency coordination, and its impact on intended use, system and group performance (Palen, 2008; Jones, 2004; Chen, 2004).

Objective Centred Solution Though EMIS technology is at a place where it can provide solutions and work-arounds, the challenge of organizational interoperability extends beyond a mere lack of agreement or understanding of collective activities. *Our objective is develop a tool that helps evaluate the effective utilization of EMIS to achieve the purpose of supporting coordinated real-time decision making*. The artefact should be informed by the complexity of the domain and tightly bound to the expertise of emergency managers with the responsibility of procuring and maintaining EMIS for their jurisdictions.

Navigation between the problem and solution spaces through concept mapping generated an awareness of the issues most relevant in EMIS utilization while also contributing to the formation of criteria for the solution. The product of the mapping exercise is a more constrained construction of a solution objective based on the identification and formulation of a relevant problem. The next section frames our understanding of the objects and relations that are seen-drawn-and seen during reflective conversation in the problem and solution spaces.

Organizational Mindfulness, EMIS Utilization, and Team Performance

The criticality of decisions requires that EMIS, with GDSS capabilities, demonstrate a capacity to provide information in a format that supports rapid processing while illustrating the elements necessary for analytical reasoning for both individuals and groups collectively. The section is intended to provide the constructs which inform the DSR study with a brief overview of theorizing outputs which inform the research framework.

Understanding Emergency Information Systems in the Application Domain

Research suggests that EMIS cater to a wide spectrum of organizations, jurisdictions, and settings both within operational centres and on-scene at emergency incidents (Turoff et al. 2004; Belardo et al, 1998). Decisions made within an operational centre are often made among an assigned group of individuals representing diverse levels of expertise or functional knowledge, who have a level of authority to commit resources and baseline understanding of the processes of their respective organizations (McLean, 2013). Various models have been used and adapted to characterize EM decision making by super imposing theories to address the challenge of individual and group perception, judgement, consensus, and cooperation to make decisions to prevent or respond to crisis (c.f. Harnesk et al. 2009; Rodríguez et al. 2009; Turoff et al. 2004; Bharosa et al. 2010; Lee et al. 2012). Kendra & Wachtendorf (2003, pg. 51) described decision making within the operational centre as an "artisanal craft" that "allow[s] for people to deploy rapidly adaptive strategies… the ability to become inspired by features in the surrounding environment, and to translate those inspirations into creative and innovative actions." Conversely, the majority of IS literature on how EMIS are used to support EM operations have focused on broad ranges of analysis related to system design, characteristics and functionality (see Van de Wall et al, 2009; Bharosa et al, 1984). These works have helped demonstrate the capabilities of technology to support communication, coordination, information sharing, and decision making without a framework to form a basis for evaluating the effectiveness of the technology to support performance. The first objective of the solution was to undertake a process to categorize EMIS according to adherence to expected attributes of the systems to be clear on the type of specialized system attributes we intend to evaluate. While there is some consistency on the complexity of problems with technology use for the EM domain, our objective was to limited focus on the components of EMIS which support decision making.

A major problem with specialized systems in this domain is the constant need for valid, real time data and information about hazardous and threatening situations to communicate across multiple organizations (Palen et al. 2007). Interestingly enough, IS research viewing organizational mindfulness (OM) as a capability-based method of inquiry and interpretation supports technological evolutions which reinforce organisational cognitive processes enabled by advanced system computational abilities. OM is considered a demonstrable capability to discover and manage unexpected events through the use of organisational cognitive processes which requires EMIS to demonstrate a capability to perform a range of tasks (Amaye, et al, 2015), and used in this study as a kernel theory to inform the study. The only way that we can understand the effectiveness of existing systems intended for this environment is to consider not only the conditions of its use, but also the alignment of those systems within dynamic processes occurring in that environment. HROs represent both a uniquely diverse domain of industries, with a common form of engagement between systems, people, and processes which engaged end user group differently. The idiosyncrasies of the environment and experiences of the researcher allows us to approach the design task through a solution conjecture as opposed to a problem analysis where the framing and perception of the problem is in terms of the design of a relevant solution (Cross, 1999). The next section describes the core kernel theory that is used to navigate drifting between the problem and solution spaces presented in the investigation of EMIS utilization.

Organizational Mindfulness in the Application Domain

Organizational mindfulness is viewed in this research as the kernel theory for understanding Information processing and response is a cornerstone of decision making, serving as a bases for the framework development. Organizational Mindfulness (OM) is a capability for rich awareness of discriminatory details that facilitates the discovery and correction of potential accidents based on five processes observed in high reliability organizations (Weick, Sutcliffe, & Obstfeld, 1999). The originating strategies intended for individual improvement: attention to context and attention to variability identified by (Langer, 1989) were expanded into a broader collective capacity of awareness and activity when investigating these cognitive processes in adaptable, reliable organizations (Weick, 1999). EM organizations embody the characteristics of HROs prime to adapt to change through the use of routine and mindful processes and approaches for the appropriate response to emergencies. The following table provides a description of the OM five processes which are attributed to the collective cognition observed within HROs which build a capability for awareness and activity.

Mindfulness Process	Organizational Cognitive Process

Preoccupation with failure	Increased attentiveness to all failures which offer opportunities to assess the health of the system, analyze near failures and focus on reliability of the system.
Reluctance to simplify interpretations	Use of methods to increase awareness of complexity from divergent perspectives preserved by system and process redundancies.
Sensitivity to Operations	Maintenance of situational awareness which provides an integrated picture of operations in the moment based on perception, synthesis, and projection.
Commitment to Resilience	Capacity to "bounce back" from unanticipated dangers after they occur and surprises in the moment through the use of informal networks and improvisation.

Table 1 Organizational Mindfulness Processes (Weick et al, 1999)

It is argued that each OM process contributes to the collective level of awareness that constantly evolved because of the information or cues which are continuously scrutinized or analysed to interpret and respond accordingly within dynamic environments. A number of organizational science and management studies have investigated the distinctive attributes of OM within the EM domain highlighting its appropriateness as a kernel theory for the study. Within the IS research community, two approaches of interest have emerged for the application of system based mechanisms that enable mindful processes. The first, proposed by Butler & Gray (2006) applied the concept to IS as a strategy for individual and organizational system use to achieve reliable performance with broader implication for better interpretation of system design, management and operation. This revealed the appropriateness of mindfulness as a lens to understanding reliable performance from an IS perspective. The second approach from Van de Walle & Turoff (2008) viewed OM as a capability-based method of inquiry and interpretation enabling technological evolutions for DSS use in EM and information security particularly. This paper concurs with these two perspectives to recognize OM as an organisational state of being supported through the maintenance and engagement of decision processes which enable specific capabilities. By framing the research through a capability-based approach proposed in the design and operation of GDSS for EM, system functionality and features facilitate mindful anticipation or containment lead to a capability to discovery and management of unexpected events critical in the domain. Figure 3: Mindful Infrastructure for High Reliability proposed by Van de Walle and Turoff (2008) is illustrated below to illustrate how OM is seen as an organizational capability guided by processes that support the anticipation or containment of unexpected events. This guides an understanding of OM processes working through cognition and organizational process to build a decision making capacity among groups using EMIS.

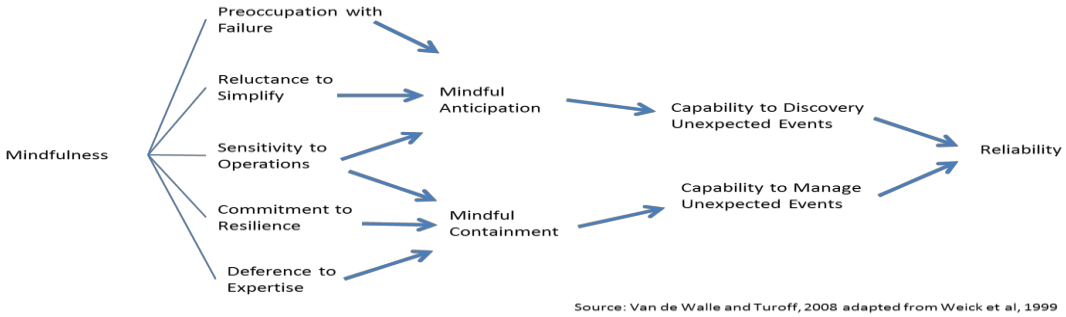

Figure 3 Mindful Infrastructure for high reliability (Van de Walle and Turoff, 2008 adapted from Weick)

On both individual and organizational levels, mindfulness theory has been used to present ways for information processing and response in changing environments. This theoretical perspective has contributed greatly to our understanding cognitive-based processing which are engaged by individuals and groups to adapt to uncertainty. In a review of operations and organizational management literature, mindfulness continues to be well documented in its occurrence in high reliability organizations (HROs) which use IS to discover and manage unexpected events (Vogus and Sutcliff, 2015). Building on this

research, EMIS utilization is seen as an intervening variable between the system and teams which perform together to anticipate or contain unexpected events which often have critical life safety implications. The next section provides a discussion of utilization to address the study problem formulation within the application domain.

System Utilization in the Application Domain

When considering the technological constructs which impact performance, Trice and Treacy (1988) argued for the intervening role of IS utilization. They formulated an approach to IS utilization research based on the Theory of Reasonable Action where utilization was considered both as dependent and intervening variables in the assessment of IS performance. Our interest is in system effectiveness for performance purposes, alternate to analysis of effectiveness based on task-technology fit posited by Desanctis et al. (1987). Other researchers have suggested the use of socio-technical theory (c.f. Harnesk et al, 2009) and technological acceptance (c.f. Stefi, 2015) which do not emphasize both utilization and team performance as key measures of organizational effectiveness. We argue that utilization based on mindfulness promotes a form of coordinated real-time decision making (CRDM) which commonly occurs in this domain (Quarentelli, 1978; Dynes, 1975). The focus of this analysis considers the characteristics of EMIS technology as a backward linking antecedent variable of utilization that is forwardly linked to performance through CRDM. Based on the nature of the application domain, it serves to help solve the problem and is formulated to be the core utility theory (Veneable, 2006) to evaluate system utilization.

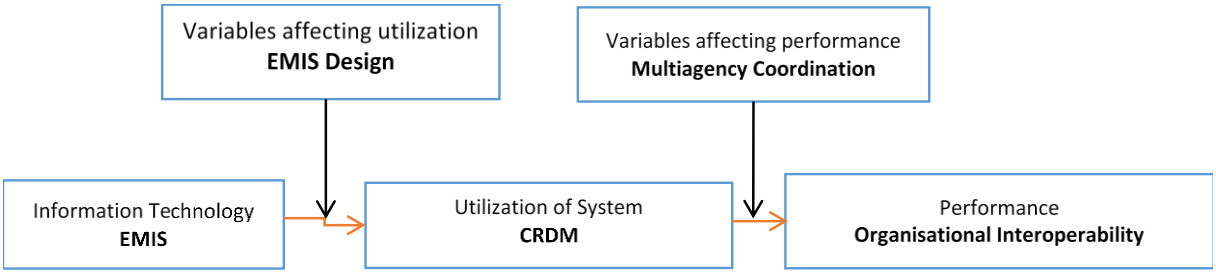

Figure 4 Utilization as an Intervening Variable (adapted from Trice and Treacy, 1988)

Traditionally, utilization of information systems in this area have focused on adoption and operations to demonstrate the capability of a system to meet the specified requirements of end users (DeLone and McLean, 2003). System utilization is conceptualized as the activity of CRDM, an intervening variable (Trice and Tracey, 1984) influenced by EMIS design and affected by the performance of multiple stakeholders representing a multi-organizational unit. EMIS utilization is the place where technology and organizational processes work together to support decision making thus enabling organizational interoperability.

Performance in the Application Domain

EMIS utilization (Trice & Treacy, 1988) is presented as occurring when real time coordinated decision making is enabled by both EMIS technology and supportive OM processes to obtain and maintain heightened awareness. CRDM is used in this investigation to describe a form of decision making unique to the EM domain due to the inherent complexities and demands of problem formation and solving during crisis. It is used here to conceptualize unique attributes and organizational structures that describe and account for the physical (McLean, 2001), functional (Perry, 2004), and technical (Bharosa et al, 2010), social dimensions (Quarantelli, 1976) of decision making within the operational centre. The DSR evaluation framework suggests that a research consider the contextual factors of goals associated with the evaluation of IS artefacts (Venerable et al, 2006). From this perspective, framing the evaluation of EMIS in the context of its designed utility for achieving the purpose of decision support serves to meet a central purpose of DSR evaluation. While decision making is seen as a single component of performance in the interest of understanding EMIS utilization, significant research suggests that this is a core function of EMIS in these settings (Belardo, Karwan, & Wallace, 1984; Curnin, Owen, Paton, & Brooks, 2015; Turoff et al., 2004).

This allows for the construction of a framework whereby we can conceptualize the construction of the IS artefact for the purpose of evaluating the execution of OM processes. Figure 4 illustrates the research model

used help our consideration of the utility and kernel theories which inform our understanding of the problem and solution spaces. Organizational mindfulness is embedded onto the utilization model to illustrate the capability driven process associated with the conceptualisation of domain attributes and study constructs (Gregor and Jones, 2007). The model represents the product of design drifting and reflective conversation of the problem and solution space in the application domain and abstraction of the research framework to organize the construction of the IS artefact. The concepts generated and defined would contribute to the theoretical and pragmatic needs for domain specific process-oriented design. OM provides a theoretical lens to design EMIS intentionally, assess utilization, and examine performance in a methodically positioned manner to meet the needs of developers and practitioners simultaneously.

The design of the artefact through a methodological orientation that employs OM as a kernel theory focuses on the attributes associated with decision making within the domain which focus on building an awareness of a situation in order to manage the consequences caused by that situation. Artefact conceptualization draws together OM and system utilization theory to visually represent the problem and solution space. EMIS utilization as CRDM is manipulated into constructs for the DSR study, which are highlighted in the case study research model in Figure 5. Schön (1992) described four facets to the design process as a reflective conversation which draw together to create the first presentation of the design construct based on the perception, appreciation, language, and active manipulation in the world in which objects and relations function (pg. 22). The research model for this DSR is a manifestation of that processes and presented as a product of the process to integrate and visualize the problem and solution space through the theoretical lens which view EMIS utilization as a capability based process affected by OM and impacting performance.

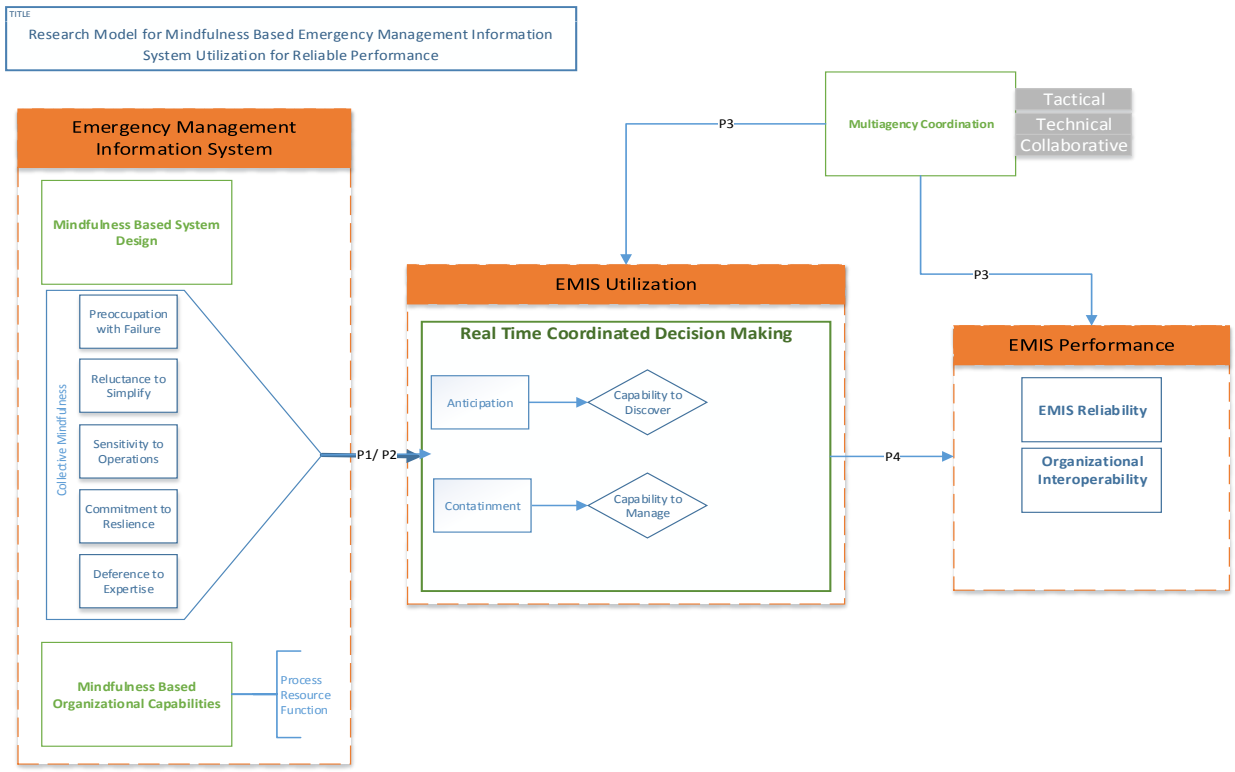

Figure 5 Research Model (created by researcher)

Problem Understanding and Constructs Validation

This section discusses the process used to validate mentally objectified abstractions of the problem space. This serves the purpose to visualize accumulated knowledge of OM to form an abstract conceptualization pertinent to the creation of an IS artefact (Cross, 1999). In describing the movement from early solution

conjecture, we explore and define the problem and solution space together through the engagement of stakeholder groups in pilot studies focused on the validation of both.

Reflective Conversations for Problem Formation

The researchers engaged in a series of two workshops at a European Security Research conference in November 2015 in Dublin with subject matter experts working on EU funded emergency management and security projects. The workshop, "Enabling Real Time Coordinated Decision Making in Emergency and Crisis Management Workshop," was facilitated in manner to validate concepts extracted during problem identification and the use of an ex-ante, naturalistic simulation format. Workshop attendees were informed that the workshop would be an open-ended interactive simulation to identify the most important features and functionalities of EMIS that enabled real-time coordinated decision making in crisis and emergencies situations. 15 individuals participated in a three part simulation workshop, illustrated in figure 6. The first segment provided an overview of the research, obtaining consent for participation, and completion of a pre-workshop questionnaire. The questionnaire intended to identify and match the skill sets of participants with roles they would "play" during the simulation. Once participants were designated a role and group, an overview of organizational mindfulness and EMIS system capabilities was provided. Participants were provided instructions for the simulation segment of the workshop.

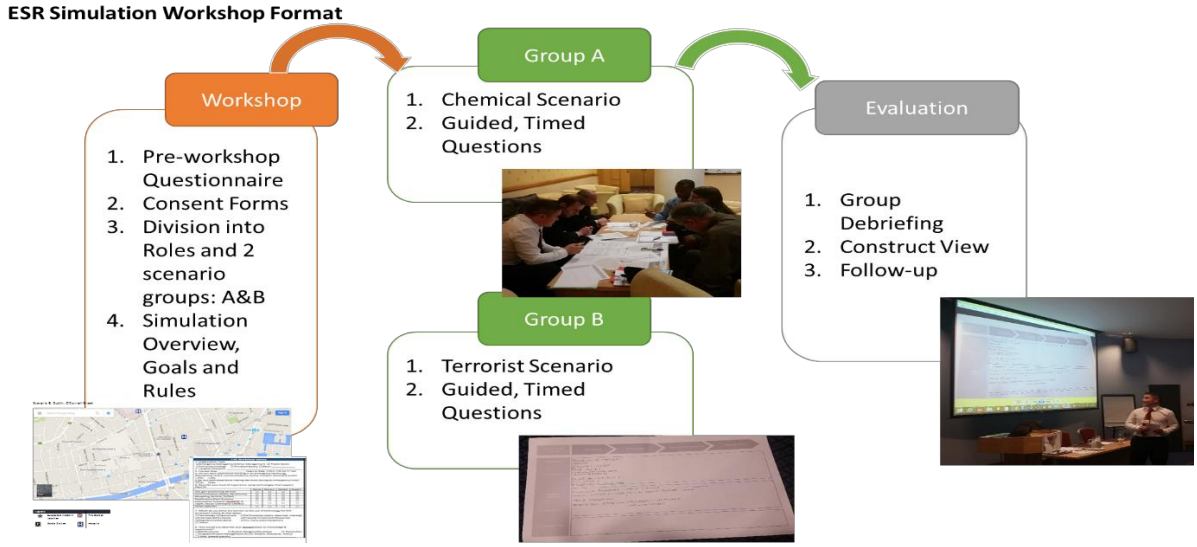

Figure 6 ESR Simulation Workshop Format

Two scenarios were used to simulate a response to a no-notice chemical incident and advance warning suspected terrorist incident, as described in Table above. Participants were guided through discussions using a journey map to address the following question: What are the processes and systems which impact decision making during active preparedness? Participants then engaged in discussion s to identify the organizational processes, EMIS capabilities, and visual requirements for an operational centre to have collective situational awareness. Participants were encouraged to consider external issues, such as politics or escalating circumstances, which may influence their actions and decisions through scripted injects. The final segment of the workshop brought the groups together to discuss their decision points and system capability selection in the form of a debriefing session. Participants were asked to evaluate the flow of the workshop, the materials used during the simulation, and the plausibility of the scenario during the session.

Table 2.0 Scenario Overview

	Scenario A (Orange)	Scenario B (Green)
Overview	Chemical incident caused by the transportation of hazardous materials	Suspected chemical bombing by a terrorist group
Attributes	No-notice, infrastructure impact, cross-border engagement	Advanced warning, business and media interface, risk communication

Decision Constraints	Life/safety, environmental, immediacy	Life/safety, environmental
Participants	• EM Personnel (P): anyone with a background in EM/CM/DM • System Developers (Y): system designers, developers, and researchers • Program Management (G): EU project admin staff, standards people • Other (W)	

In reflecting on the use DSR in the initial design of the evaluation framework revealed the need for a focused approach to the area of decision making for EM purposes. By isolating the tasks to those associated with real-time coordination of resources, processes, and communication, we were able to engage in a plausible, yet highly focused dialogue within small groups. Considering organizational processes which are enabled by specialized systems with a broad range of features and functions for situational awareness, it was necessary to guide discussion in a flexible, yet organized manner. The evaluation framework intends to characterize, from a qualitative perspective, aspects of effective utilization of EMIS for coordinated decision-making, towards the achievement of real-time information processing and scanning. To that end, DSR provides a methodology which will allow for the design construction to be validated by intervention with end-user groups and organizations engaged in the utilization of EMIS

Considering Utilization as an Intervening Variable

Multiagency coordination enabled and supported by EMIS presents a series of structural problems that Information System Design Theory (ISDT) may solve in the design and production of artefacts for this class of systems. Similar to the challenge Walls and Sawy (1992) confronted, the theoretical basis by which EMIS capabilities relate to performance measures and link to design guidelines are not well understood in the literature. The workshop survey used for the ESR event was modified and used to survey a contingent of participants of the United National International Strategy Disaster Risk Reduction (UNISDR) Science and Technology Conference 27-29 Janurary, 2016 in Geneva, Switzerland. The survey sought to engage with a stakeholder group of subject matter experts representing an international contingency of over 450 EMIS users, stakeholders, and researchers. A sample of thirty random conference participants were approached to participate in the survey, providing responses using a tablet linked to Survey Monkey. The researcher selected members of the conference at random through a systematic process of approaching every 10th person within the open conference space. The conference was identified as an appropriate location to help establish a case for relevance of the proposed research and design presenting the conceptual research model framework for the artefact. During this poster session presentation, the researcher also asked conference attendees who participated in the session to respond to the survey. The survey allowed the researcher to gain closer insight into the experiences of attendees in using systems for emergency management decision-making to understand the technologies most considered useful in those efforts, as well as see what attendees considered to be the pressing priorities of the Sendai Framework. The survey consisted of 9 questions including closed and open ended questions. During the poster session, the researcher answered questions about mindfulness, real time decision making enabled by systems, and the evaluative framework concept. After questions were answered, attendees were asked if they would be interested in participating in a short survey about the research.The goal of the pilot survey was to gather sentiment of the variables which affected EMIS utilization and validate the relevance of the problem formulated during the artefact conceptualization stage. The knowledge building process in DSR is described by Owen (1997) as a generating and accumulating process where action becomes the medium for the design process. Knowledge about the EM domain gathered from years as a practitioner and engagement with practitioners is intended to be used to build a case for the relevance of the designed artefact. What is revealed in engagement with practitioners at the UNISDR Science & Technology conference is there is a level of awareness of ICT applications, platforms, and systems within the domain and clear expectation of its use to support EM operations.

Validation of the Research Model

Our investigation focuses on CRDM among strategic level decision makers representing diverse organizations, each with their own respective structures, resources, and functional focuses. We proposed the use of scenario-driven simulation exercises to observe EM processes and activities and gather empirical data to guide the convergence of this integrative approach to IS and EM research. We applied aspects of this framework during a pilot workshop in November 2015 using an emergency scenario exercise and facilitated discussion to evaluate an approach that focused on anticipation and containment oriented

decision making. The pilot provided validation of the simulation format which encouraged expanded scanning, context relevant interpretation and information analysis (Fiol and O'Conner, 2003) through a time-sensitive selection process. The research model serves as the final step of blue printing the conceptualization of the artefact integrating topics and considerations relevant to the application environment. The use of the simulation workshop allows for the construction of the artefact with a rigor for the attributes associated with how the artefact would be administered within the environment. The novelty is not in the use of a simulation or survey to validate the research constructs, but in the intricate processes of design praxeology which allows for cognitive speculation to enable abductive reasoning in artefact conceptualization. Nestled within the creative process are the tools and approaches valuable to understand the problem space and orient a solution that is prescribed by continual engagement and iterative construction. Organizational mindfulness is viewed as a highly cognitive set of processes which are engaged on a sensory level, yet observed on a physical plane through the interactions, attitudes, and behaviours of groups of individuals within this application domain. Design is informed by the relevance of the technical attributes in the functions, features, and capabilities of EMIS to support coordinated real time decision making in a meaningful way.

Ideation Process, Next Steps, and Conclusion

The purpose of this paper was to provide insight into design praxeology which occurs in the problem identification and artefact conceptualization stages of DSR. The design drifts between the problem formulation and solution design space to develop mental representations of the first application of the artefact prior to the design of the actual artefact. This section provides an illustration of ideation processes and the initial iteration of the evaluation framework.

Drifting and Reflective Conversation Process

What happens as a part of the problem discovery are conceptualizations of objects and relations which are formed as a consequence of understanding the influencing complexities associated in a designated problem space. These objects may highlight many of the problems which are to be explored for the domain. Problem formulation through design drift and reflective conversation allow for a focus on solving a mystery of sorts about how systems are used in the decision making process when life safety priorities are paramount. The objective becomes the construction of the missing link to solve the problem. Consequently the only way to know if the artefact works is to evaluate how it fairs in the evaluation framework setting-artificial or natural. Figure 7: Design Drift and Reflective Conversation Process Diagram illustrates the process taken in the problem formulation stage of this DSR study.

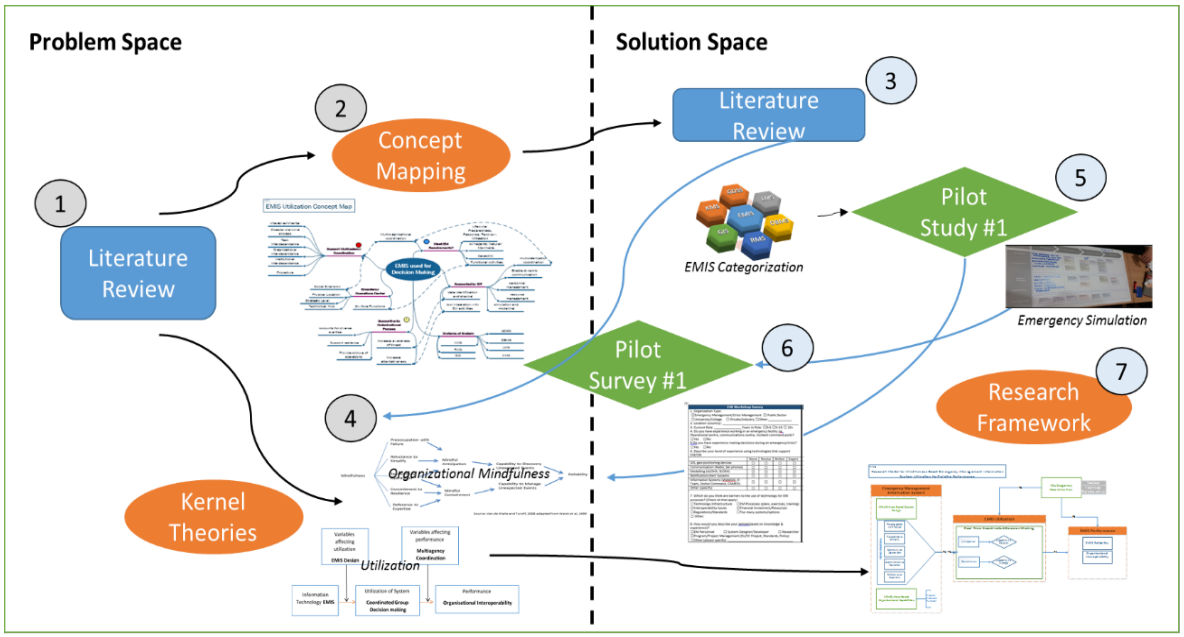

Figure 7 Design Drift and Reflective Conversation Process Diagram

The diagram illustrates design drifting with black arrows, stemming from a review of the literature to the building of initial concept maps. Reflective conversations are indicated by blue arrows where concept maps and kernel theories inform the review of literature for EMIS design dimensions to the facilitation of the two pilot studies. The final drift occurs through an active manipulation of collected information about the problem and solution space. The goal of the paper was to improve an understanding of design praxeology, and the activities of engaging in reflective conversation and concept mapping serve as outputs of that process. While one is highly contextual, the other offers a visualization of the contextualized problem which is then presented through engagement with members of the application domain. Building relevance in the Design stage is proposed in this case through the pilot study and survey, first to validate constructs of the study and second to validate assumptions of EMIS utilization by groups. Just as other stages of DSR are shaped by engagement with potential end users, this research does that in an interactive manner to obtain a higher awareness of the needs of the intended user of the artefact. The engagements aid in design drifting by providing touch points to modify assumptions about the proposed artefact as well as the process for the construction and implementation of the artefact within the application domain. What is well understood through this approach is that building knowledge about utilization of EMIS for coordinated real-time decision making can only occur through engagement with the practitioners for which the artefact is intended to assist. They will be able to direct and guide the artefact's attributes in a way that informs research and appeals to their specific need to build an organizational capacity with a clear return on investment for the EMIS which are integrated in their operations. Reflective conversation is described as an activity that a designer engages in to respond to the demands of a conceived problem with creativity to materialize the constructs and reconstructions of objects and their relationships in the design process (Schön, 1992). While it is described in literature as an individual, subjective task, the researcher used it as a form of design praxeology to engage in group discussion around the topic of crisis and emergency management and technology.

Limitation of Drifting and Reflective Conversation in Problem Formulation

While there are substantial methodological benefits in presenting design drift and reflective conversation as an approach to problem formulation, there are also limitations which are unique to the design process in general, and this case in particular. First, tacit knowledge allows for the richness of abductive contemplation and cognitive speculation. For a designer who is not oriented or remotely acquainted with the application domain, it would difficult to derive the elements and variables which would be most relevant to an objective oriented solution. Often times developers are called into an organization to help design and build a system without the a priori knowledge of the domain which ultimately influences and impacts the

use of information systems. The use data collection techniques like the survey and workshop provide for an external validation of the highly subjective assumptions which frame the design space and influence the design process. Knowledge obtained using these techniques require iterative subjective circumscription to construct meaning within context and yet, it remains an elusive reminder of the ontological and epistemological orientation of design as a science. Truth is derived from multiple realities contextually situated in states that are socio-technologically enabled. Second, this case is representative of a unique application domain where group cognition affects technology utilization in concrete ways with impactful outcomes on the ability of organizations to protect the communities at times of crisis, emergency, and disaster. Organizational mindfulness is selected as a kernel theory to constrain design drift and focus reflective conversation onto framing the problem and solution space in a step-wise fashion. The research seeks to communicate an approach to navigate through the ebbs of abstraction and flows of ideation for the sake of creation, progress, and understanding. To that end, the research illustrates that, bound to DSR as a method, are opportunities to reveal a process for reasoning that can be expressed, and should be expressed in our research.

Another attribute which is revealed in this case study focused on the EM application domain, which can be seen as a limitation to generalizability, is in the area of access for the purpose of design. The environment of many HROs are highly secure, many are identified as critical infrastructure like nuclear facilities or fire stations, so the ability to access the level of decision makers who are engaged in CRDM is a privilege. Potential barriers to access for the research team are alleviated by virtue of being a member of the EM community, which allows for participants in the research with the comfort that they are "talking to one of their own." The focus of this paper is in the study of the processes and practices of design, and the techniques and tools which have been suggested are the elements of the research which offer rigor and generalizability for that purpose. The use of the concept map to contextualize the phenomena of interest and iterations of design drift and reflective conversation are proposed to frame the problem and solution space. Ultimately, it is to the discretion of a researcher to reveal the process of ideation, and that is where this research is situated. By providing a case example of design praxeology we are able to remove some of the subjective mystery associated with the abstraction in abductive reasoning. Techniques which occur within the landscapes of the mind manifest the visual and physical representations of the creative process, one which is can remain elusive, but doesn't have to be. The multiple dimensions and directions that the designer flows between to contextualize an objective oriented solution are varied, and should be, as the design process is an intimately dynamic one which can and should engage with members of the application domain. To that end, the research offers an approach that is generalizable in that the designer should impose purposeful opportunities to validate the assumptions, preconceptions, and notions about a problem at multiple points of the design stage. By fixating on iterative expressions of design praxeology, the designer is able to rely on the steps similar to those proposed by Hevner (2007) using mapping and modelling techniques which guide DSR, and transmit both the constructed artefact and the process of its design in a more complete way.

Next Steps

Using the DSR methodology, we have used design drift and reflective conversation to construct an interpretation of constructs within an application domain which inform how the problem and solution spaces converge in artefact construction. This research contributes to two areas of the DSR methodological paradigm. The first is in the use of design tools and methods to explore the intervening nature of utilization, discovering more about the role, nature, and use of IS artefacts which are embedded in organizational operations. The second is exploring and communicating the praxeological process a designer undergoes in the materialization of contextual concepts to support the formation of an IS artefact intended for evaluation of other designed artefacts. Problem formulation becomes the enveloping seed allowing the solution to germinate within the mind of the designer, building the application framework for the designed instantiation. The core focus of our research is the support provided by EMIS for CRDM and team performance supporting a claim that decision making is a capability which can be measured for the purpose of understanding effectiveness in reliable performance. When reliability in organizational performance is positioned at the centre of system design and operations, we propose that assessing the effectiveness and impact of GDSS on the EM domain will become more possible. This study describes the initial stage of conceptualization and construction of an IS artefact which intended to solve that problem.

This research served a specific purpose of providing a methodological approach to the ideation and conceptualization challenges associated with the design stage of Design Science Research. The proposed

techniques, tools, and approaches serve as outputs which serve the purpose of the intended research into EMIS utilization for coordinated real time decision making. Discussing the ebbs and flows of the design process offers to the research community, an avenue for continued dialogue about the "how" of design. Whether the design of an artefact is done by an individual or by a group, what is encouraged here is continued contemplation about the space in which the artefact is situated and adherence to the empirical requirements for relevance and rigor in all aspects of DSR. The EM domain is uniquely complex and to an outsider tasked or commissioned to design an artefact for the space, it can be extremely daunting. The research output in the form of an evaluation framework to support the design and evaluation of EMIS for reliable performance comes from an acute awareness of the challenges experienced by practitioners in using these technologies. While it is recognized that not every researcher will be able to access members and stakeholders within every application domain, this research proposes ways to engage with the study population at an early stage of the ideation process in order for validation. That is not unique to DSR, and our case study presents the use of a simulation workshop as a way of bringing subjects into the design process for the purpose of problem formulation. This allows for the proposed artefact to be created from the shared experiences and knowledge base of its intended users, building internal validity for the design drift and reflective conversation as mechanisms for design praxeology. The stages of reclusive contemplation are exposed and enriched through engagement with domain members for this case study. The novelty is not in its occurrence, but the transparency in which it is communicated to the DSR community at large to encourage dialogue about how we study the practices and processes of design.

While the study presents the process for a specific application domain, it is in the illustration of the process to approach artefact conceptualization that is communicated for the benefit of the research community. By removing some of the mysticism often associated with abductive reasoning, we can be more effective in using cognitive tools and communicating approaches to illustrate the inferential processes that are unique to DSR. Design drift and reflective conversation are just two which have been proposed to identify a specific problem with socio-technical systems used for the EM domain. The next phases of the research build upon them through three iterative design cycle for the construction of the artefact using scenario-based simulations with EM practitioners. The enhancement of our knowledge of utilization and performance using DSR as a methodological approach does more than complement this study, but also engages in the purposeful solution seeking that the research paradigm endeavours to express.

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